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Impact of Kinnow Peel Extract As Natural Preservative In Carrot-Kinnow Juice Blend

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Carrot (*Daucus carrota*) belongs to the *Umbellifereae* family while Kinnow (*Citrus reticulata Blanco*) belongs to the family *Rutaceae*. The present study was conducted to evaluate the preservative effect of Kinnow peel extract with different percentage (5%, 10%, 15 %) of peel extract and compared with sodium metabisulphite. The quality of juice with peel extract was analyzed by its physico-chemical properties compared juice with synthetic preservative sodium metabisulphite (SMS. *The proximate composition, total phenolic content (TPC), antioxidant activity (DPPH), pH, total soluble solids (TSS), and mineral content of dried Kinnow peel were analyzed*. The total phenolic content of Kinnow peel was extracted by using three different organic solvents *i.e.* hexane, methanol and ethanol at various samples to solvent ratios as 1:10, 1:15 and 1:20 in case of each organic solvent. Ethanol concentration shows higher extraction yield and was used for further analysis while lowest value obtained in methanol at 1:20 concentration. In the second part of the study, a carrot-Kinnow juice blend was selected as per treatment plan based on consumer liking which was 25% Kinnow and 75% carrot. Afterwards, various concentrations of Kinnow peel extract with higher total phenolic content were added in various dose patterns *i.e.* T_1 (5%), T_2 (10%), T_3 (15%) and then compared with T_0 synthetic preservative *i-e*, sodium metabisulphite 70ppm through its preserving role. The results regarding physico-chemical analysis of carrot-Kinnow juice blend with sodium metabisulphite (SMS) showed total phenolic content (TPC) i.e. (124.96±0.02 mgGAE/100g, 124.96±0.02 mgGAE/100g, 121.55±0.03 mgGAE/100g and 119.23±0.03 mg GAE/100g) pH results were (5.97±0.06, 6.26±0.03, 6.46±0.05, and 6.71±0.08) total soluble solids (TSS) results were (15.8±0.02, 16.3±0.02, 16.6±0.02 and 17.03±0.02), total flavonoid content (TFC) were (43.5±0.01, 47.16±0.01, 42.63±0.01 and 41.72±0.02 mg QE/100g), titratable acidity (TA)% were (0.45±0.02, 0.48±0.02, 0.45±0.02 and 0.42±0.01), DPPH assay (47.48±0.02%, 44.97±0.01%, 44.39±0.02%, and 42.52±0.02%) at 0, 7th 14th and 21st days of storage. Treatment T_3 (15% Kinnow peel extract) demonstrated the highest sensory acceptability, including superior appearance, taste, and overall quality, (TPC) i.e. (124.96±0.02 mgGAE/100g, 124.96±0.02 mgGAE/100g, 121.55±0.03 mgGAE/100g and 119.23±0.03 mg GAE/100g) pH results were (6.17±0.01, 6.46±0.01, 6.66±0.01, and 6.94±0.08) total soluble solids (TSS) results were (17.03±0.15, 17.43±0.47, 17.73±0.11 and 17.73±0.05), total flavonoid content (TFC) were (42.63±2.20, 36.64±0.01, 41.72±1.09 and 38.47±0.76 mg QE/100g), titratable acidity (TA)% were (0.38±0.01, 0.36±0.01, 0.37±0.01 and 0.38±0.01), DPPH assay (47.48±2.58%, 44.97±2.49%, 41.72±1.09%, and 38.99±1.44%).

Keywords: Total phenolic content, solvent dilutions, synthetic preservative, physico-chemical and sensory quality.

INTRODUCTION

From ancient civilizations onward, food preservation has been a major concern in human history. To prolong the shelf life of food, ancient societies created a variety of preservation techniques, such as drying and salting (Sharif *et al.*, 2017). In modern societies, chemical preservatives, such as benzoates, nitrates, nitrites, and sorbates are frequently employed for food preservation. Nonetheless, there have been worries raised over the possible harm that excessive preservative use could do to people's health (Zhang *et al.*, 2021). Concerns about the health effects of highly processed and altered food items, which are frequently loaded with artificial preservatives, have led to a rise in the usage of natural

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preservatives (Novais *et al.,* 2022). Food innovations that balance providing all organoleptic qualities with guaranteeing food safety and health are therefore becoming more and more necessary. The food industry has modified its recipes to suit contemporary lifestyles to satisfy this demand (Khan *et al.,* 2023). Recent years have seen a concentrated emphasis on biopreservation. There is a diverse selection in natural preservative field that increase nutritional characteristics and physiochemical properties of food (Soltani *et al.,* 2021). The main purpose for the addition of natural preservatives is to increase their shelf life. They are added intentionally to food for the improving of intrinsic characteristics such as antimicrobial, antioxidant, and stabilizing substances (Soutelino *et al.,* 2024). Biopreservatives are known as natural preservatives, obtained from different plants, insects and even bacteria (Taylor *et al.,* 2020). Natural preservative obtained from Kinnow peel extract offers significant implications for enhancing food safety and extending shelf life. Kinnow peel is rich in bioactive compounds that confer both antimicrobial and antioxidant properties, making it a valuable candidate for use in food preservation (Nadeem *et al.,* 2023). Studies have demonstrated that phenolic-rich extracts, such as those found in citrus peels, can effectively mitigate protein oxidation and improve protein solubility, thereby enhancing the overall quality of food products (Sharma *et al.,* 2024). Furthermore, the application of Kinnow peel extract in food not only addresses the need for natural alternatives to synthetic preservatives but also aligns with consumer demands for safer and healthier food options. Previous research indicates that the use of citrus peel extracts can prevent oxidative changes in food, thereby retaining its quality over time (Bishnoi *et al.,* 2022). For instance, Kinnow peel extract has been successfully incorporated into salted chicken patties, demonstrating its efficacy in preserving freshness during storage (Al-Dalali *et al.,* 2019). Additionally, the potential to develop active food packaging materials using citrus peel extracts is a promising avenue for further research, as it could enhance the shelf life of various food products while maintaining their sensory properties (Durmus *et al.,* 2024). Collectively, these findings underscore the viability of Kinnow peel extract as a natural preservative, not only contributing to food safety but also providing a sustainable approach to food preservation in the industry.

Beverages are an essential part of the human diet. It contains healthy nutrients that fulfil the daily requirements of the body. Blending natural fruit and vegetable juices creates a nutritious and healthy beverage. The production concept of fruit juice beverages was practically unknown till 1930. After that fruit juice production trend in industry increases gradually. During hot summer fruit beverages serve as a cold drink appetizer in tropical countries. They have more nutrition value as compared with synthetic cold drinks that are produced on large scale in industries. Fruit drinks have several advantages over artificial and aerated beverages in terms of nutrition, ease of digestion, refreshingness, and appetizingness (Srivastava *et al.,* 2005). Due to their improved sensory and nutritional qualities, fruit juices and fruit-based products are in high demand. This can be accomplished by blending or mixing different fruit juices, which can also help overcome the high cost of seasonal fruits and their limited supply. Blending can also help balance color, sourness, strong flavors, pungency, bitter taste, total soluble solids, and phytochemical properties that help regulate sugar/acid ratios and compensate for detrimental juice uniformity (Meena *et al.,* 2021). Instead of consuming a single fruit or vegetable for a single vitamin, nutrient-dense mixed fruit and vegetable juice can provide the most nutrients in a combined form at a time. Consuming antioxidant-rich foods lowers the risk of cardiovascular, neurological, and inflammatory illnesses, as well as preventing some types of cancer and muscle deterioration (Daly *et al.,* 2010). Carrot-Kinnow juice has a great taste, is nutritious, and is refreshing. Combining carrot and Kinnow in a juice blend creates a synergistic beverage that capitalizes on individual nutritional profile of both ingredients. Carrots, renowned for their high beta-carotene content that body converts into vitamin A, are celebrated for supporting eye health, boosting immunity, and promoting skin vitality (Meena *et al.,* 2021). Kinnow, a citrus fruit like oranges, are loaded with vitamin C and bioactive compounds that contribute to immunological defense, improved collagen synthesis, and cardiovascular support (Sharma *et al.,* 2017).

The current study is designed to evaluate the preservative effect of Kinnow peel extract and formulation of acceptable carrot-Kinnow blend.

MATERIALS AND METHODS

***Raw material*:** Kinnow fruit was purchased from the local market of Multan. The standards and chemicals were acquired by the Department of Food Science & Technology, MNS-University of Agriculture Multan.

***Proximate analysis of Kinnow peel*:** Determination of proximate composition like crude fat (method no. 30-10) using Soxhlet apparatus, crude protein (method no. 46-10) by Kjeldahl apparatus, crude fiber (method no. 32-10), ash (method no. 08-01) using Muffle-furnace and moisture (method no. 44-15A) in Hot Air Oven of oven dried Kinnow peel were carried out in accordance to AOAC (2019).

***Mineral analysis*:** Sample was used to determine mineral profile by using the methods of AACC (2016). Sodium and potassium were analyzed by using flame-photometer while zinc, calcium, magnesium and iron were analyzed by atomic absorption spectrophotometer.

***pH*:** The pH of the Kinnow peel was recorded by dipping the pH meter's bulb into the sample according to the procedure of AOAC (2019).

***Total soluble solids (TSS)*:** The total soluble solids (TSS) content of the peel samples was measured by utilizing a

handheld digital refractometer (CE7400 S, Germany), as detailed in Bhardwaj *et al*. (2011).

***Total phenolic content (TPC)*:** The Kinnow peel for TPC determination was evaluated by using Folin-Ciocalteu phenol reagent method (Shehata *et al.,* 2021). A deionized water and Folin-Ciocalteu reagent were added in Kinnow peel sample. After 6 minutes, Na_2CO_3 (7% w/v) and distilled water were added at ambient temperature. Absorbance was checked against blank reagent at 716 nm.

***2, 2-Diphenyl-1-picrylhydrazyl (DPPH) assay*:** The calculation of free radical scavenging activity of Kinnow peel was measured by use of spectrophotometer with the procedure adopted by (Godara *et al.,* 2020). DPPH solution was made by dissolving 5.9 mg of DPPH in 100 mL of ethanol. This prepared solution of DPPH was then added in 0.2 mL Kinnow peel in amount of 3.8 mL. Mixture was kept at normal room temperature in dark area after continuous shaking for about 1 minute. Absorbance was found at 517 nm in contradiction of black indicator at 517 nm.

***Titratable acidity %*:** According to AOAC (2019), a method was used to calculate the titratable acidity (TA). A 100 mL graduated beaker was filled with a total of 10 mL of diluted Kinnow peel, along with a couple of drops of phenolphthalein indicator. A faint pink color eventually developed after adding 0.1N NaOH to the prepared sample. Titratable acidity (TA) of the sample were determined using the formula mentioned below:

$$\text{Titratable acidity \%} = \frac{0.0064 \times \text{Volume of NaOH used}}{10} \times 100$$

***Extraction of Kinnow peel extract*:** The extract of oven dried Kinnow powdered peel was extracted by using maceration method indicated by (Elfalleh *et al.,* 2012). After minor adjustments, Initial research was conducted to obtain the most effective sample to solvent ratio by making dilutions @ 1:10, 1:15 and 1:20 at room temperature. Following the initial investigations, the phenolics was extracted by using hexane, ethanol and methanol. A sample of 5-g oven dried Kinnow peel powder was extracted in a shaking water bath for 20 hours using a particular solvent, centrifuged at 4000rpm for duration of 6 hours. After collecting the supernatant, the solvent was evaporated under vacuum using a rotary evaporator bath temperature was 34 ºC, 120 revolution per minute for 18 minute to produce extract. Then the extraction was filtered through filter paper before being preserved in glass bottles.

***Determination of total phenolic content (TPC)*:** The extract of Kinnow peel for TPC determination was evaluated by using Folin-Ciocalteu phenol reagent method (Shehata *et al.,* 2021). A deionized water and Folin-Ciocalteu reagent were added in Kinnow peel sample. After 6 minutes, Na_2CO_3 (7% w/v) and distilled water were added at ambient temperature. Absorbance was checked against blank reagent at 716 nm.

Product development:

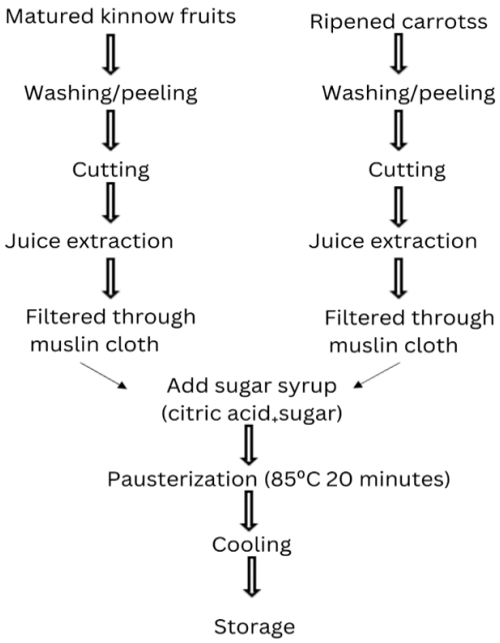

Figure 1. Methodology for preparing carrot-Kinnow juice blend.

***Sensory evaluation*:** Nine hedonic measures were used to assess the sensory evaluation of carrot-Kinnow juice blends, including taste, color, mouth feel, aftertaste, bitterness, appearance and overall acceptability (Kumar *et al.,* 2014).

***Preparation of carrot-Kinnow juice with different formulations*:** Fresh 6 kg carrots were chosen, intact, dust-free, peeled, cleaned, cut, and processed in an electric carrot juicer machine. The juice afterward passes over a muslin cloth to get opaque liquid. Almost 750ml juice was extracted. Healthy and fully developed 8 kg Kinnow were chosen, cleaned, and cut into two halves. The manual extraction of juice was done, and the extracted juice was filtered using a muslin cloth to produce clear juice. Almost 500 ml Kinnow juice was extracted. Then make a blend according to treatment (T_3) mentioned in Table 1 with a concentration of 75% carrot and 25% Kinnow in a 250 ml of 4 glass bottles. Then a necessary quantity of citric acid and sugar were deliquesced in water to make sugar syrup up to the point of boiling and then cooled to a TSS of 14–20º Brix. The sugar syrup was then mixed with a carrot and Kinnow juice blend. Then sodium metabisulphite 70ppm were added in bottle 1 named as T_0, 5% extract 2ml were added in bottle no.2 named as T_1, 10% extract 2.5ml were added in bottle no. 3 named as T_2 and 15% extract 3ml were added in 250mL glass bottle named as T_3. Then the juice was blended, pasteurized for 20 minutes at 85 °C, and cooled for 10 minutes. The bottles were disinfected for 30 minutes set at 80 °C hot water bath cooled and stored at refrigeration temperature *i-e.,* 5°C.

***Sensory evaluation and storage study*:** Prepared value-added product was stored for the period of 21 days. The storage study and sensory evaluation was carried out at 0, 7th, 14th, and 21st day of storage. Analysis of the value-added product including pH, total soluble solids (TSS), total phenolic content (TPC), viscosity, DPPH assay and total flavonoid content (TFC), were conducted once every 7 days over the course of 21 days. Ten trained persons evaluated the juice blend using Nine Point Hedonic, considering their appearance, smell, taste, color, bitterness, aftertaste, mouth feel and overall acceptability.

***Stastical analysis*:** All analysis carried out and then statistical analysis were done to evaluate and determine the significant difference among treatments (Montgomery, 2017). Using Statistix 8. 1, two-way factorial design ANOVA (analysis of variance) were performed on the data derived (analytical software). Each sample was divided into three replicates, a significant difference of 0.05 were calculated in a statistical analysis manner.

RESULTS

Proximate analysis of Kinnow peel powder raw material showed different percentages of moisture content, ash, fat, fiber, protein and NFE percentages mentioned in Table 1. All the findings were closed match with (Rafiq *et al.*, 2019) with moisture mean value 4.93 ± 0.09%, ash with 0.57 ± 0.04%, fat with 1.22 ± 0.02%, fibre with 0.59 ± 0.07%, protein with 0.63 ± 0.06% and NFE 92.06 ±0.01. The value of pH, titratable acidity (TA), total soluble solids (TSS) of the Kinnow peel was close match with (Hasan *et al.*, 2022), the mean value of total phenolic content (TPC), DPPH assay and mineral content findings closed match with (Rafiq *et al.*, 2019).

Table 1. Proximate percentage, physico-chemical analysis and minerals parameters.

Moisture	7.93 ± 0.01
Ash	3.01 ±0.01
Fat	0.22 ±0.02
Fiber	1.84 ±0.03
Protein	0.55 ±0.01
NFE	86.45 ±0.02
pH	6.05±0.01
TSS(°Brix)	11.0±0.2
Titratable acidity %	3.61±0.11
Total phenolic content (mg GAE/100g)	689.69±0.01
Antioxidants (DPPH)%	63.41±0.01
Potassium (K)	150.30±0.01 mg/100g
Sodium (Na)	184.81±0.56 mg/100g
Calcium (Ca)	180.13±0.01 mg/100g
Zinc (Zn)	0.41±0.01 mg/100g
Iron (Fe)	5.39±0.01 mg/100g

The findings of extract through different solvent extraction methods mentioned in Table 2. The extraction of total phenolics yield higher in using solvent ethanol are close match in contrast with the outcomes of (Safdar *et al.*, 2017). There are different techniques of polyphenols extraction by using different solvents the two commonly used are maceration technique and UAE (Ultrasound assisted technique). Different solvents with different techniques showed different outcomes depending upon which technique was used. So, the maceration technique with ethanol 80% resulted yield (18.46%), with solvent ethanol ratio 50% yielded (15.64%), but with the solvent 100% ethyl acetate the extraction yield was the lowest (5.12%). Total phenolic content of hexane with ratio 1:10, 1:15 and 1:20 sample-to-solvent dilution shows results with mean values of 175.5113±0.231 mgGAE/100g, 165.0433±0.22 mgGAE/100g and 359.926±0.23 mgGAE/100g respectively. Total phenolic content of methanol with ratio 1:10, 1:15 and 1:20 sample-to-solvent dilution shows results with mean values of 464.3463±0.23 mgGAE/100g, 506.2087±0.23 mgGAE/100g and 127.6044±0.23 mgGAE/100g respectively. Total phenolic content of ethanol ratio 1:10, 1:15 and 1:20 sample-to-solvent dilution shows results with mean values 226.6727±0.23 mgGAE/100g, 555.9765±0.23 mgGAE/100g and 620.16±0.23 mgGAE/100g respectively. (Al-Juhaimi, 2014) showed results of mandarin peel polyphenols extracted through maceration technique was in contrast with ethanol 80% at 70ºC for 3 hours, resulted 169.53 mg GAE/100g, orange resulted as 178.90 mgGAE/100g, and lemon peel resulted as 178.90 mgGAE/100g. These outcomes were higher than the concentrations present in pulp.

Table 2. Mean value of total phenolic content of Kinnow peel extract.

Solvent		Dilutions (Sample*: Solution)	Mean value (mg GAE/100g)
	H_1	1:10	175.51±0.23
Hexane	H_2	1:15	165.04±0.22
	H_3	1:20	359.92±0.23
	E_1	1:10	226.67±0.23
Ethanol	E_2	1:15	555.97±0.23
	E_3	1:20	620.16±0.23
	M_1	1:10	464.34±0.23
Methanol	M_2	1:15	506.20±0.23
	M_3	1:20	127.60±0.23

***Sensory analysis*:** The term "descriptive sensory evaluation" refers to a group of approaches used to differentiate between various products based on all their sensory attributes and to develop a quantitative measure of all the sensory properties that may be found, not only the defects. Contrary to traditional quality assessment methods that use scorecards, the review's objective is different; hence no evaluation of "good" or "poor" is made. When traditional methods are applied, goods with a

wide range of sensory characteristics but no faults were given the same grade. This review lacks sufficient information to fully understand the physical and chemical reasons behind sensory characteristics and the differences in sensory qualities that could be crucial for consumer acceptance. Sensory tests are crucial in assessing the quality of food from the consumer's perspective.

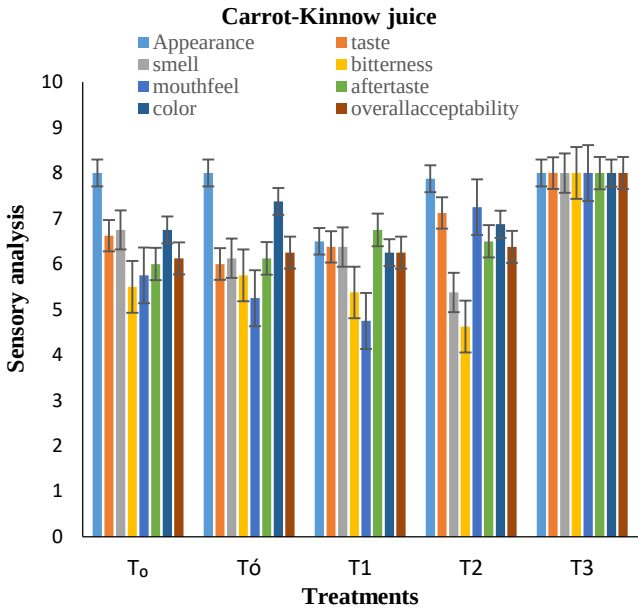

Figure 2. Sensory evaluation of carrot-Kinnow juice blends.

The results showed that treatment (T_3) showed highly significant mean value of 8.00±0.00. Juice with 75 % carrot and 25% Kinnow was highly acceptable analyzed by highly qualified researchers. So, the treatment (T_3) was used for further product development and compared as described in section (preparation of carrot-Kinnow juice with different formulations) for storage study and statistical analysis.

***Storage study*:** A shelf-life study of the product was done at seven days of interval *i.e*, 0, 7th, 14th and 21st day. The product was analyzed all the physico-chemical analysis and viscosity throughout the storage period mentioned in Table 3.

***Acidity level*:** According to the findings of (Meena *et al.,* 2021) acidity of different carrot-Kinnow juice treatments show 0.42±0.03- 0.47±0.03%. While according to (Kumar *et al.,* 2014) the acidity of juice blend's acidity level was 0.31%. The storage study revealed that the acidity of carrot-Kinnow juice increased over time. The acidity value of carrot-Kinnow juice with synthetic preservative (T_0) was 0.46±0.05, 0.48±0.03, 0.35±0.05, and 0.35±0.03 at seven days of interval up to 21st day of storage. The acidity value of (T_1) with 5% Kinnow peel extract was 0.42±0.08, 0.45±0.03, and 0.38±0.011 and 0.42±0.01 at seven days of interval to the 21st day of storage. The acidity value of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 3.51±0.02, 3.51±0.02, 3.41±0.05 and 3.22±0.04 of storage. The acidity value of (T_3) in which Kinnow peel extract was 15% show 4.11±0.03, 4.11±0.03, 3.94±0.04 and 3.41±0.05 of storage up to 21st day.

***Total flavonoid content*:** The results of (Meena *et al.,* 2021) show that the total flavonoid content (TFC) level of various carrot-Kinnow juice blend show 47.55± 0.07. The storage study revealed that the total flavonoid content (TFC) of carrot-Kinnow juice decreased over time. The flavonoid content of carrot-Kinnow juice with synthetic preservative (T_0) was 43.50±0.05, 47.76±0.03, 47.63±0.05, and 42.63±0.03 of storage. The total flavonoid content of (T_1) with 5% Kinnow peel extract was 47.16±0.08, 43.50±0.03, and 42.63±0.011 and 43.50±0.01 of storage. The flavonoid content of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 42.63±0.02, 41.72±0.02, 42.63±0.05 and 41.72±0.04 of storage. The flavonoid content of (T_3) in which Kinnow peel extract was 15% show 42.63±0.03, 43.50±0.03, 41.72±0.04 and 37.03±0.05 of storage up to seven days of interval to the 21st day.

***pH*:** The storage study revealed that the pH of carrot-Kinnow juice increased over time. The pH value of carrot-Kinnow juice with synthetic preservative (T_0) was 5.97±0.06, 6.26±0.03, 6.46±0.05, and 6.71±0.08 of storage. The pH value of (T_1) with 5% Kinnow peel extract was 6.07±0.01, 6.26±0.03, and 6.52±0.011 and 6.83±0.01 of storage. The pH value of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 6.12±0.02, 6.45±0.02, 6.62±0.01 and 6.92±0.01 of storage. The pH value of (T_3) in which Kinnow peel extract was 15% show 6.17±0.03, 6.46±0.03, 6.66±0.04 and 6.94±0.05 of storage. The outcomes of and (Meena *et al.,* 2021; Kumar *et al.,* 2014) are in accordance with the results of my study.

***DPPH assay*:** The results of (Meena *et al.,* 2021) show that the DPPH antioxidant level of various carrot-Kinnow juice blend show 58.84± 0.11. The storage study revealed that the acidity of carrot-Kinnow juice decreases over time. DPPH assay of juice sample containing synthetic preservative (T_0) storage was 43.51±0.01, 47.76±0.03, 47.63±0.05, and 42.63±0.03. The % inhibition of (T_1) with 5% Kinnow peel extract storage was 47.16±0.08, 43.50±0.03, and 42.63±0.011 and 43.50±0.01. The antioxidant level of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 42.63±0.02, 41.72±0.02, 42.63±0.05 and 41.72±0.04 of storage. The level of (T_3) with 15 % Kinnow peel extract at storage results was 42.63±0.03, 43.50±0.03, 41.72±0.04 and 37.03±0.05.

***Total soluble solids*:** (Meena *et al.,* 2021) results of TSS at storage level was 16.08±0.03. Whereas (Kumar *et al.,* 2014) findings was 17.0±0.05%. From the researchers' results and according to my findings it was revealed that the TSS increases with the time of storage. Values with synthetic preservative (T_0) storage was 15.8±0.05, 16.3±0.03, 16.6±0.05, and 17.3±0.03. The 5% (T_1) Kinnow peel extract was 16.3±0.08, 16.6±0.03, and 17.3±0.01 and 17.4±0.01 at

Table 4. Storage study of carrot-Kinnow juice blend stored at 5ºC.

Parameters	Storage period (days)	Treatments				Storage means
		T_0	T_1	T_2	T_3	
Total phenolic content mg GAE/100g	0	124.96	258.30	198.84	258.30	144.56c
	7	124.96	207.22	197.98	205.43	163.94b
	14	121.55	197.98	136.05	197.98	178.51b
	21	119.23	136.05	121.55	119.23	194.40a
	Treatment means	122.68c	163.61b	195.23a	199.89a	-
pH	0	5.97	6.07	6.12	6.17	6.082d
	7	6.26	6.26	6.45	6.46	6.359c
	14	6.46	6.52	6.62	6.66	6.565b
	21	6.71	6.83	6.92	6.94	6.850a
	Treatment means	6.350c	6.420b	6.529a	6.557a	-
Titratable acidity %	0	0.45	0.44	0.45	0.38	0.432a
	7	0.48	0.35	0.38	0.36	0.393b
	14	0.45	0.35	0.34	0.37	0.378bc
	21	0.42	0.34	0.34	0.38	0.370c
	Treatment means	0.4500a	0.3733b	0.3783b	0.3725b	-
DPPH	0	47.48	50.82	51.93	47.48	49.43a
	7	44.97	47.48	51.84	44.97	47.31a
	14	44.39	47.48	44.24	41.72	44.46b
	21	42.25	44.36	42.54	38.99	42.10b
	Treatment means	44.84b	47.53a	47.63a	43.29b	-
Total flavonoid content (QE/100g)	0	43.50	46.76	47.63	42.63	45.13b
	7	46.73	55.26	58.26	36.64	49.22a
	14	42.49	42.49	41.72	41.72	42.11bc
	21	41.72	37.03	38.99	38.47	39.05c
	Treatment means	43.617ab	45.388a	46.65a	39.86b	-
TSS (Brixº)	0	15.80	16.30	16.60	17.03	16.433c
	7	16.30	16.60	17.03	17.43	16.842b
	14	16.60	17.03	17.43	17.73	17.200a
	21	17.03	17.43	17.73	17.73	17.483a
	Treatment means	16.433c	16.842b	17.200a	17.483a	-

Mean followed by different letters are significant ($p<0.05$); Each value is average of minimum three replicates

same time interval of seven days till 21st day of storage. Treatment with (T_2) 10% Kinnow peel extract was 17.6±0.02, 17.3±0.02, 17.4±0.05. Whereas the treatment with (T_3) 15% Kinnow peel extract was 17.3±0.03, 17.4±0.03, 17.6±0.04 and 17.7±0.05 at same duration of seven days till 21st day of storage.

***Viscosity*:** The storage study revealed that the viscosity of carrot-Kinnow juice remains same over time and decreases on the 21st day of storage. The viscosity of carrot-Kinnow juice with synthetic preservative (T_0) was 8.5±0.05, 8.5±0.03, 8.5±0.05, and 7.0±0.03 storage. The viscosity of (T_1) with 5% Kinnow peel extract was 8.5±0.08, 8.5±0.03, and 8.0±0.011 and 7.5±0.01 of the storage. Carrot-Kinnow juice (T_2) viscosity with 10% Kinnow peel extract was 8.5±0.02, 8.5±0.02, 8.0±0.05 and 7.5±0.04 of storage. The viscosity of (T_3) in which Kinnow peel extract was 15% show 8.5±0.03, 8.5±0.03, 8.0±0.04 and 8.0±0.05 storage. The findings are similar with (Yusuf *et al.*, 2023) 8.4±0.9, 7.8±0.6, 7.4±0.6 and 6.9±0.00 during storage study.

In this investigation, the mean values for carrot-Kinnow juice blend's TPC, pH, titratable acidity (TA), antioxidant DPPH assay, total flavonoid content (TFC), total soluble solids (TSS), and viscosity were determined to be 127.98±0.246, 3.37±0.05, 0.47±0.03, 58.84±0.11, 47.55±0.07, 17.03±0.107, and 400±0.202, respectively. These outcomes close matches to the outcomes of (Gómez-Mejia *et al.*, 2023; Meena *et al.*, 2021; Ullah *et al.*; Kumar *et al.*, 2014; Bhardwaj and Mukherjee, 2011) discovered.

***Appearance*:** The most insightful feel of any product is its appearance. The appearance effected during storage period of carrot-Kinnow juice blend with different storage duration. T_0 (synthetic preservative) at storage showed a mean value of 8±0.00, non-significant with mean value 6.83±0.23 at seventh day, 7±0.00, 6.83±0.23 at twenty first day with non-significant mean value. T_1 (5% extract) showed highly

significant value of 7±0.00, 6.83±0.23, 7±0.00, 6.83±0.23. T_2 (10% extract) at storage showed highly significant value of 8±0.00, 7±0.00, 7±0.00 and non-significant mean value at twenty first day storage 6.83±0.00. T_3 (15% extract) showed 8 ±0.00, 8±0.00, 8±0.00 and non-significant at 21st day with mean value 6.83±0.23. The results of sensory appearance in ANOVA showed highly significant results and non-significant with comparison of days and treatment as mentioned in Table 4. The difference is due to the pigments present in juice at storage conditions. These outcomes are close match with the results (Rani *et al.,* 2020; Arora *et al.,* 2023).

***Smell*:** The softest feel of any product is its smell. The smell significant mean value at twenty first day storage 6.83±0.00. T_3 (15% extract) showed 7±0.00, 6.83±0.23, 5.83±0.23 and non-significant at 21st day with mean value 5.83±0.23. The results of sensory taste in ANOVA showed highly significant results and non-significant with comparison of days and treatment as mentioned in Table 4. The difference is due to the pigments present in juice in storage conditions. These outcomes are close match with the results (Rani *et al.,* 2020; Arora *et al.,* 2023).

Table 5. Storage study of carrot-Kinnow juice blend stored at 5ºC.

Parameters	Storage period (days)	Treatments				Storage means
		T_o	T_1	T_2	T_3	
Appearance	0	8.00	6.83	7.00	6.83	7.750a
	7	7.00	6.83	7.00	6.83	7.250a
	14	8.00	7.00	7.00	6.83	7.166a
	21	8.00	8.00	8.00	6.83	6.833c
	Treatment means	7.1667b	6.916c	7.208b	7.708b	-
Taste	0	6.83	6.00	5.83	5.00	6.916a
	7	7.00	5.83	6.00	5.00	6.166b
	14	6.83	6.00	5.83	5.00	5.875c
	21	7.00	6.83	5.83	5.83	5.208d
	Treatment means	5.916b	5.958b	5.916b	6.375a	-
Bitterness	0	5.00	5.00	5.00	5.00	4.598a
	7	5.00	5.00	5.00	5.00	4.598a
	14	5.00	5.00	5.00	5.00	4.598a
	21	4.83	4.83	4.83	4.83	4.598a
	Treatment means	5.000a	5.000a	5.000a	4.833a	-
Mouth feel	0	5.00	6.00	5.83	5.00	5.458a
	7	5.00	5.00	5.00	5.00	5.208b
	14	5.00	6.00	4.83	5.00	5.000c
	21	5.00	5.00	5.00	5.00	5.000c
	Treatment means	5.500a	5.167b	5.000c	5.000c	-
Aftertaste	0	5.00	5.00	4.33	5.00	5.000a
	7	5.00	4.33	5.00	4.33	4.917a
	14	5.00	5.00	4.33	5.00	4.917a
	21	5.00	4.33	5.00	4.00	4.917a
	Treatment means	4.958a	4.958a	4.917a	4.9167a	-

Mean followed by different letters are significant ($p<0.05$); Each value is average of minimum three replicates

close match with the results of (Rani *et al.,* 2020; Arora *et al.,* 2023).

***Taste*:** The most demanding feel of any product is its taste. The taste effected during storage period of carrot-Kinnow juice blend with different storage duration. T_o (synthetic preservative) at storage showed a mean value of 6.83±0.00 at 0 day, non-significant with mean value 6.00±0.00 at seventh day, 5.83±0.23 with non-significant, and 5±0.00 at twenty first day with significant mean value. T_1 (5% extract) showed highly significant value of 7±0.00, 5.83±0.23 non-significant, 6±0.00, 5±0.00. T_2 (10% extract) at storage showed highly significant value of 6.83±0.23, 6±0.00, 5.83±0.23 and non-effected during storage period of carrot-Kinnow juice blend with different storage duration. T_o (synthetic preservative) at storage showed a mean value of 6±0.00, highly significant with mean value 6±0.00 at seventh day, 5±0.00, 5±0.00 at twenty first day significant mean value. T_1 (5% extract) showed highly significant value of 6±0.00, 6±0.00, 5±0.00, 5±0.00. T_2 (10% extract) at storage showed a highly significant value of 6±0.00, 6±0.00, 5±0.00 and highly significant mean value at twenty first day storage 5±0.00. T_3 (15% extract) showed 6 ±0.00, 6±0.00, 5±0.00 and highly significant at 21st day with mean value 5±0.00. The results of sensory smell in ANOVA showed highly significant results

and non-significant comparison of days and treatment as mentioned in Table 4. The difference in taste is due to the pigments present in juice in storage conditions. These outcomes are close match with the results of (Rani *et al.,* 2020).

***Bitterness*:** The underrated feel of any product in beverages is bitterness. The bitterness effected during storage period of carrot-Kinnow juice blend with different storage duration Limonin present in Kinnow juice effected as it converted into limonite compound results in bitterness. T_0 (synthetic preservative) at storage showed a mean value of 5±0.00, highly significant with mean value 5±0.00 at seventh day, 5±0.00, 5±0.00 at twenty first day with non-significant mean value. T_1 (5% extract) showed a highly significant value of 5±0.00, 5±0.00, 5±0.00, 5±0.00. T_2 (10% extract) at storage showed a highly significant value of 5±0.00, 5±0.00, 5±0.00 and a highly significant mean value at twenty first day storage 5±0.00. T_3 (15% extract) showed non-significant 4.83±0.23, 4.38±0.23, highly significant 5±0.00 and non-significant at 21st day with mean value 4.83±0.23. The results of sensory bitterness in ANOVA showed highly significant results and non-significant with comparison of days and treatment as mentioned in Table 4. The difference is due to the pigments present in juice in storage conditions. These outcomes are close match with the results of (Afreen *et al.,* 2016; Raza *et al.,* 2014).

***Mouth feel*:** The tastiest feel of any product is its mouth feel. The mouth feels affected during storage period of carrot-Kinnow juice blend with different storage duration. T_0 (synthetic preservative) at storage showed a mean value of 5±0.00 highly significant with mean value 5±0.00 at seventh day, 5±0.00, 5±0.23 at twenty first. T_1 (5% extract) showed highly significant value of 6±0.00, 5±0.00, 6±0.00, 5±0.00. T_2 (10% extract) at storage showed non-significant value of 5.83±0.00, 5±0.00, 4.83±0.00 and highly significant mean value at twenty first day storage 5±0.00. T_3 (15% extract) showed 5±0.00, 5±0.00, 5±0.00 at 21st day with mean value 5±0.00. The results of sensory mouth feel in ANOVA showed highly significant results and non-significant with comparison of days and treatment as mentioned in Table 4. The difference is due to the chemical pigments present in juice in storage conditions. These outcomes match closely with the results of Bhardwaj and Mukherjee (2011).

***Aftertaste*:** The feel that any person can feel is the aftertaste of any beverage product. The aftertaste effected during storage period of carrot-Kinnow juice blend with different storage duration. T_0 (synthetic preservative) at storage showed a mean value of 5±0.00, highly significant with mean value 5±0.00 at seventh day, 4.83±0.23 non-significant, 5±0.00 at twenty first day with highly significant mean value. T_1 (5% extract) showed highly significant value of 5±0.00, 4.83±0.23, 5±0.00, 4.83±0.23. T_2 (10% extract) at storage showed a highly significant value of 6±0.00, 5±0.00, 6±0.00 and highly significant mean value at twenty first day storage 5±0.00. T_3 (15% extract) showed 5.83±0.23, 5±0.00, 4.83±0.00 and highly significant at 21st day with mean value 5±0.00. The results of sensory aftertaste in ANOVA showed highly significant results and non-significant with comparison of days and treatment as mentioned in Table 4. The difference is due to the chemical pigments present in juice in storage conditions. These outcomes are close match with the results of (Rani *et al.,* 2020; Arora *et al.,* 2023).

***Color*:** The first image of any product is its color in sensory aspects. The color effected by different phytochemicals, chlorophyll and carotenoids present during storage period of carrot-Kinnow juice blend with different storage period. T_0 (synthetic preservative) at storage showed a mean value of 8±0.00, mean value 7±0.00 at seventh day, 6±0.00, 6.00±0.00 at twenty first day with highly significant mean value. T_1 (5% extract) showed highly significant value of 8±0.00, 7±0.00, 6±0.00, 6±0.00. T_2 (10% extract) at storage showed a highly significant value of 8±0.00, 7±0.00, 6±0.00 and highly significant mean value at twenty-first-day storage 6±0.00. T_3 (15% extract) showed 8±0.00, 7±0.00, 6±0.00 and highly significant at 21st day with mean value 6±0.00. The results of sensory color in ANOVA showed highly significant results and highly significant difference with comparison of days and treatment as mentioned in Table 4. The difference is due to the pigments present in juice in storage conditions. These outcomes are close match with the results of (Rani *et al.,* 2020; Arora *et al.,* 2023).

***Overall acceptability*:** The overall acceptability of any product depends upon its all-sensory characteristics. The overall acceptability effected during storage period of carrot-Kinnow juice blend with different storage duration. T_0 (synthetic preservative) at storage showed a mean value of 5±0.00, highly significant with mean value 6±0.00 at seventh day, 5±0.00, 5±0.00 at twenty first day with highly significant mean value. T_1 (5% extract) showed highly significant value of 5±0.00, 6±0.00, 5±0.00, 5±0.00. T_2 (10% extract) at storage showed a highly significant value of 5±0.00, 6±0.00, 5±0.00 and mean value at twenty first day storage 5±0.00. T_3 (15% extract) showed 5±0.00, 6±0.00, 5±0.00 and highly significant at 21st day with mean value 5±0.00. The results of overall acceptability in ANOVA showed highly significant results and a highly significant comparison of days and treatment as mentioned in Table 4. The difference is due to the pigments present in juice in storage conditions. These findings close with the results of Raza *et al.* (2012 and Arora *et al.* (2023).

DISCUSSION

(Meena *et al.,* 2021) results of TSS at storage level was 16.08±0.03. Whereas (Kumar *et al.,* 2014) findings was 17.0±0.05%. From the researchers' results and according to my findings it was revealed that the TSS increases with the time of storage. The differences in total soluble solids (TSS)

between the 70 ppm sodium metabisulphite (SMS) preserved carrot-Kinnow juice blend and the carrot-Kinnow juice with 15% Kinnow peel extract can be attributed to several key factors including higher initial TSS in Kinnow peel extract juice. Carrot-Kinnow juice with 15% Kinnow peel extract had an initial TSS of 17.03±0.15, which is already higher than the 15.80±0.2 in the SMS -preserved juice at day 0. This suggests that Kinnow peel extract itself contains more soluble solids, including sugars, organic acids, flavonoids, and pectin, which contribute to higher TSS.

Slower TSS Increase in peel extract juice compared to SMS Juice. TSS increased gradually in both juices, but the increase was slightly lower in the Kinnow peel extract juice (from 17.03±0.15 to 17.73±0.05) compared to the SMS-preserved juice (from 15.80±0.2 to 17.03±0.15). The presence of natural antioxidants and bioactive compounds in Kinnow peel may stabilize the juice composition, slowing down the breakdown of carbohydrates into simpler sugars. Kinnow peel contains more organic acids (citric acid, ascorbic acid, flavonoids, phenolic compounds), which may influence sugar metabolism in the juice. The acidic environment could slow down enzymatic activity that contributes to TSS increase. The initial TSS is higher in Kinnow peel extract juice due to its natural sugars, organic acids, and pectic substances. Over time, both juices show a gradual increase in TSS, but the SMS-preserved juice shows a greater percentage increase due to enzymatic and chemical breakdown of complex carbohydrates. The Kinnow peel extract likely stabilizes the juice composition, preventing excessive breakdown of sugars and leading to a more controlled TSS increase.

(Safdar *et al.,* 2017) showed the findings of total phenolic compounds extracted through different techniques. Kinnow peel is rich in phenolic compounds, such as flavonoids, phenolic acids, and tannins, leading to a much higher initial TPC (258.30 mg GAE/L) compared to 124.96 mg GAE/L in the SMS-preserved juice. Citrus peels contain high amounts of hesperidin, naringenin, and rutin, contributing to the higher initial phenolic content. Over time, phenolic compounds degrade due to oxidation (exposure to oxygen and light), enzymatic degradation (polyphenol oxidase activity. The Kinnow peel extract juice shows a rapid decline in TPC from 258.30 to 119.23 mg GAE/L over 21 days. This is because Kinnow peel extract contains freer phenolics, which are more susceptible to degradation compared to bound phenolics. Sodium metabisulphite (SMS) acts as an antioxidant and antimicrobial agent, which helps. As a result, the TPC in SMS-preserved juice remains relatively stable and decreases gradually (124.96 → 119.23 mg GAE/L), compared to the sharp decline in the Kinnow peel extract juice. By 21 days, both juices have nearly the same phenolic content (119.23 mg GAE/L), meaning that most free phenolics in Kinnow peel juice degraded. The SMS-treated juice maintained its phenolic content due to preservative effects. Higher initial TPC in Kinnow peel juice is due to the abundance of phenolic compounds in the peel. Faster degradation in Kinnow peel juice occurs due to oxidation and polymerization of free phenolics. Sodium metabisulphite stabilizes phenolic content, leading to a slower decline in the SMS-preserved juice. By day 21, both juices reach similar TPC values, indicating degradation of most free phenolics and retention of bound phenolics.

According to the findings of (Meena *et al.,* 2021) acidity of different carrot-Kinnow juice treatments show 0.42±0.03-0.47±0.03%. While according to (Kumar *et al.,* 2014) the acidity of juice blend's acidity level was 0.31%. The storage study revealed that the acidity of carrot-Kinnow juice increased over time. The acidity value of carrot-Kinnow juice with synthetic preservative (T_0) was 0.46±0.05, 0.48±0.03, 0.35±0.05, and 0.35±0.03 at seven days of interval up to 21st day of storage. The acidity value of (T_1) with 5% Kinnow peel extract was 0.42±0.08, 0.45±0.03, and 0.38±0.011 and 0.42±0.01 at seven days of interval to the 21st day of storage. The acidity value of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 3.51±0.02, 3.51±0.02, 3.41±0.05 and 3.22±0.04 of storage. The acidity value of (T_3) in which Kinnow peel extract was 15% show 4.11±0.03, 4.11±0.03, 3.94±0.04 and 3.41±0.05 of storage upto 21st day.

The results of (Meena *et al.*,2021) show that the total flavonoid content (TFC) level of various carrot-Kinnow juice blend show 47.55± 0.07. The storage study revealed that the total flavonoid content (TFC) of carrot-Kinnow juice decreased over time. The flavonoid content of carrot-Kinnow juice with synthetic preservative (T_0) was 43.50±0.05, 47.76±0.03, 47.63±0.05, and 42.63±0.03 of storage. The total flavonoid content of (T_1) with 5% Kinnow peel extract was 47.16±0.08, 43.50±0.03, and 42.63±0.011 and 43.50±0.01 of storage. The flavonoid content of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 42.63±0.02, 41.72±0.02, 42.63±0.05 and 41.72±0.04 of storage. The flavonoid content of (T_3) in which Kinnow peel extract was 15% show 42.63±0.03, 43.50±0.03, 41.72±0.04 and 37.03±0.05 of storage up to seven days of interval to the 21st day.

The storage study revealed that the pH of carrot-Kinnow juice increased over time. The pH value of carrot-Kinnow juice with synthetic preservative (T_0) was 5.97±0.06, 6.26±0.03, 6.46±0.05, and 6.71±0.08 of storage. The pH value of (T_1) with 5% Kinnow peel extract was 6.07±0.01, 6.26±0.03, and 6.52±0.011 and 6.83±0.01 of storage. The pH value of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 6.12±0.02, 6.45±0.02, 6.62±0.01 and 6.92±0.01 of storage. The pH value of (T_3) in which Kinnow peel extract was 15% show 6.17±0.03, 6.46±0.03, 6.66±0.04 and 6.94±0.05 of storage. The outcomes of and (Meena *et al.,* 2021; Kumar *et al.,* 2014) are in accordance with the results of my study. The results of (Meena *et al.*,2021) show that the DPPH antioxidant level of various carrot-Kinnow juice blend show 58.84± 0.11. The storage study revealed that the acidity of carrot-Kinnow juice decreases over time.

DPPH assay of juice sample containing synthetic preservative (T_0) storage was 43.51±0.01, 47.76±0.03, 47.63±0.05, and 42.63±0.03. The % inhibition of (T_1) with 5% Kinnow peel extract storage was 47.16±0.08, 43.50±0.03, and 42.63±0.011 and 43.50±0.01. The antioxidant level of carrot-Kinnow juice (T_2) with 10% Kinnow peel extract was 42.63±0.02, 41.72±0.02, 42.63±0.05 and 41.72±0.04 of storage. The level of (T_3) with 15 % Kinnow peel extract at storage results was 42.63±0.03, 43.50±0.03, 41.72±0.04 and 37.03±0.05.

Given that citrus peels, in particular owing to their composition, low prices, and readily availability. As a result, this approach enables the acceptance of a circular economy strategy that provides environmentally sound options to dispose of citrus wastage, encouraging the agri-food industry to engage in healthier grown and eaten goods.

In given the research results, it is encouraged that the bitterness, aftertaste, and mouth feel of carrot-Kinnow juice blend with Kinnow peel extract different concentrations can be improved by using standards of procedures. Overall acceptability of the carrot-Kinnow juice blend with different treatments shows different acceptability. It can be environment friendly. By using natural preservative of Kinnow peel extract as a best alternate to synthetic preservative. But due to different cultures, environmental conditions, and consumer acceptability further research will be needed to improve its acceptability.

***Conclusion*:** The impact of Kinnow peel extract as a natural preservative on different treatments can be influenced by various experimental conditions, including temperature, processing conditions and storage conditions. It's important to note that various outcomes may affect the outcomes and restrict the widespread applicability of the results. Additionally, external factors like transportation, distribution and consumer handling practices were not considered in this study. These factors can have an influence on the quality attributes of carrot-Kinnow juice blend in real-world situations.

It is dire need to explore the environmentally friendly and natural substitutes for natural preservatives in fresh fruit mixes. As well as evaluate the feasibility of plant-derived natural preservative or other functional ingredients that can provide comparable advantages while satisfying consumer preferences for natural and transparent labeling of product.

***CRediT author statement*:** Sara Khan was responsible for the conceptualization of the study, supervision, project administration, and writing of the original draft, and also served as the corresponding author. Ambreen Naz contributed to the methodology design, data analysis, and manuscript review. M. Sibt-e-Abbas assisted in experimental procedures, data collection, and technical validation. Gulzar Akhtar supported the research by contributing to the horticultural aspects, resources, and interpretation of findings. Nosheen Naz provided input on nutritional aspects, reference management, and manuscript proofreading. All authors read and approved the final manuscript.

***Conflict of interest*:** The authors declare no conflict of interest

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***SDGs addressed*:** Good Health and Well-being, Industry, Innovation, and Infrastructure, Responsible Consumption and Production

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